# Technical Memorandum

**To:** Henry Chen, PE, Cascade Water Alliance

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**Project:** Water Treatment Plant Treatment Technology: Regulatory and Feasibility Update

**Date:** April 30, 2020

**Subject:** Task 110: Water Treatment Plant Feasibility Study Update **Final**

# 1. Introduction

Lake Tapps is an off-channel reservoir located in Pierce County that was created in 1911 to produce hydropower. Cascade Water Alliance (Cascade) began negotiations with Puget Sound Energy (PSE) to acquire the reservoir in 2001 with the intent of converting it to a municipal water supply source. In December 2009, Cascade became the new owner and manager of Lake Tapps Reservoir and the related Lake Tapps-White River hydroelectric project facilities. Cascade is planning to construct a new water treatment plant (WTP) above the Kent-Auburn Valley, just west of Lake Tapps. The water right is for 75 cubic feet per second (cfs) average (48.5 million gallons per day [mgd]) and 135 cfs peak (87.3 mgd). The new WTP will be capable of producing potable water with peak capacities of 43.6 mgd in 2040 and 87.3 mgd in 2050.

Cascade realizes that there have been changing water regulations, improving treatment technologies, and changing processes since the earlier version of a technical memorandum (TM) for a WTP feasibility study that was conducted in 2001. The conditions and operating characteristics of Lake Tapps have also changed over the years. The purpose of this TM is to identify appropriate treatment technologies and processes for the Lake Tapps WTP based on Lake Tapps Reservoir water quality and treated water goals established in the Task 100 TM.

# 2. Approach

A potential treatment process has been developed based on the results of the Task 100 TM (HDR 2020), which established treated water goals for the WTP after examining the following:

- Recent water quality analysis conducted by Herrera Environmental Consultants at Lake Tapps Outlet on November 12–14 and December 17, 2019
- Water quality analysis from the United States Geological Survey (USGS) *2012 Quality of Water in the White River and Lake Tapps* report conducted at the Lake Tapps Outlet Station during May to December 2010
- Current and pending drinking water quality requirements as per Washington State Department of Health (DOH) in Washington Administrative Code (WAC) Chapter 246-290
- Federal drinking water quality requirements that have been promulgated or proposed by the U.S. Environmental Protection Agency (EPA)

- Finished water quality from Seattle Public Utilities (SPU) water supply and Tacoma Water (TW) water supply
- Potential man-made contaminants that might develop in Lake Tapps Reservoir

Lake Tapps Reservoir is not presently being used as a source of potable water. Therefore, source protection and control measures, per DOH requirements, have not been applied to this reservoir.

In addition, naturally occurring contaminants will likely be present in the Lake Tapps Reservoir. One that is unique to this surface water, compared to the Tolt, Cedar, and Green Rivers, is glacial flour that finds its way into the White River from melting Mount Rainier glaciers. Because a small fraction of the glacial flour will not have settled out within the reservoir, the proposed treatment process must be capable of removing these very small particles.

Other sources of particulates include sediment carried by the White River during the high flow season and stormwater runoff along the reservoir shoreline and flowline.

Although the basic water chemistry of the White River is similar to that of the Tolt, Cedar, and Green Rivers, treating the water from Lake Tapps Reservoir will be somewhat more challenging than treating the water from these other sources because of the glacial flour and anticipated higher levels of other organic substances. Because of the shape and bathymetry of Lake Tapps Reservoir and the location of inlets and outlets, some areas of the reservoir are not as well flushed as other areas.

Many technologies available in the market can be selected to treat the water conditions in Lake Tapps Reservoir. The key features for the selected treatment process are as follows:

- It will include a positive-barrier process to provide reliable treatment for the removal of naturally occurring contaminants such as glacial flour, algae, and natural organic matter (NOM).
- The treatment goal is finished water that will meet water quality targets, customer acceptance, and requirements for blending with water supplies from other utilities.
- It will provide a process that can be effective for meeting the requirements of pending and anticipated future drinking water regulations, including known emerging contaminants.
- It will provide a process that can accommodate future modifications/additions to the treatment process.
- It will minimize the number of unit processes needed to achieve a reliable positive-barrier treatment process to reduce capital and operation and maintenance (O&M) costs. In addition to contaminant removal, it will minimize disinfection by-product (DBP) precursors upstream of the disinfection step.
- The facility should fit on the available site with sufficient room for expansion and/or additional processes (if required). The unit processes can be expanded so that the WTP capacity can be constructed in phases while minimizing costs.
- It will provide a process that meets the project hydraulic head requirements considering inlet and outlet conditions, ground elevations, piping, and pumping.

# 3. Project Location

As per the previous TM titled *Review of Plant Physical Size and Location Requirements,* dated 2005, the future WTP will be located west of Lake Tapps, between the PSE electrical substation and the old hydropower plant. Existing systems such as the forebay, reservoir intake, tunnel, and penstock will be used to convey raw/untreated water to the WTP. Figure 1 shows the area allocated for the WTP, which is approximately 83 acres.

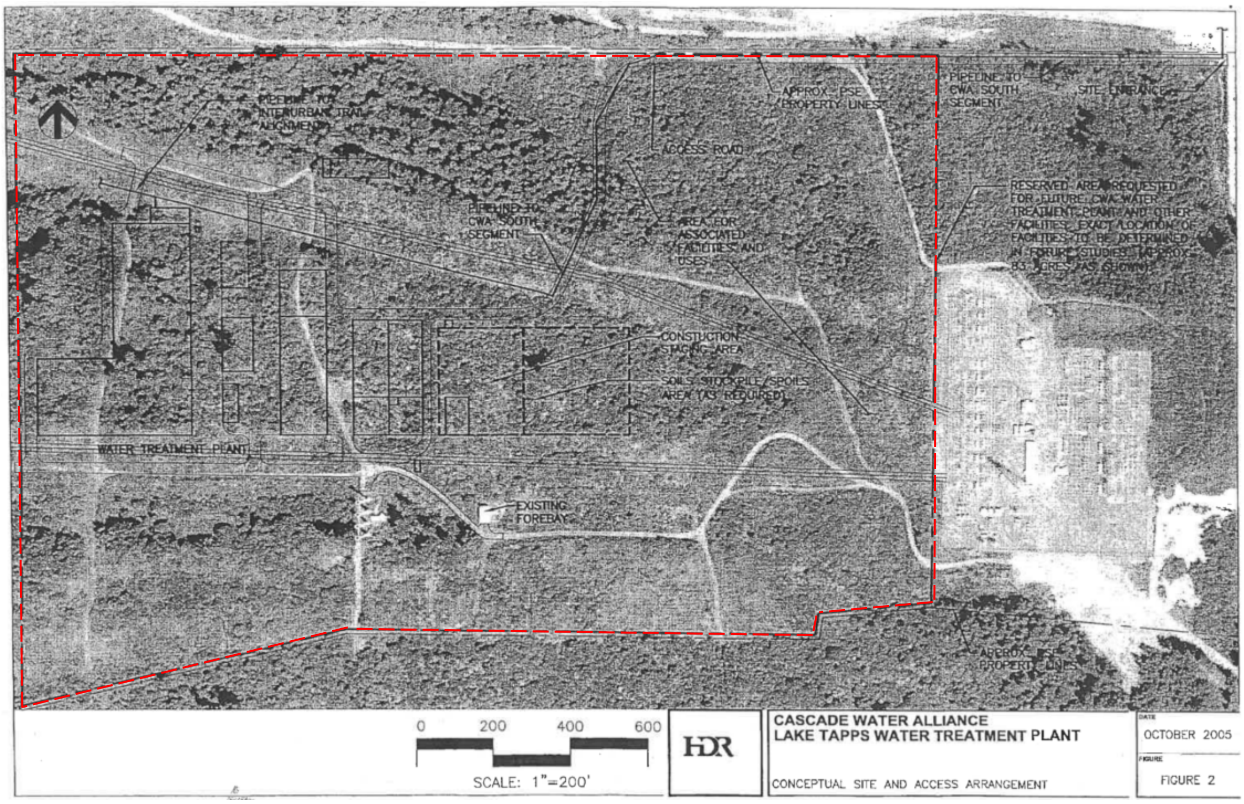


**Figure 1. Lake Tapps WTP conceptual site location highlighted in red marker**

Source: HDR 2005.

# 4. Project Capacity

The WTP production capacity will be as follows:

- **2040:** 50 percent of 48.5 mgd average and 50 percent of 87.3 mgd peak
- **2050:** 48.5 mgd average and 87.3 mgd peak

# 5. Treatment Process Selection

The selected treatment process will be composed of several unit processes operated in series to achieve a positive barrier treatment. A variety of treatment configurations can be used to remove or reduce the undesirable constituents from source water; each treatment stage plays an important role at the various stages of the treatment train.

## 5.1 Filtration

There are two filtration treatment processes are those used for surface water treatment in the Pacific Northwest: granular media filtration and media filtration. Below are examples of existing treatment facilities using these treatment process and their rated peak capacities.

- **Granular media filtration:** This treatment process is the predominant one in the Pacific Northwest and throughout North America. The following are examples of media filtration WTPs:
  - Washington:
    - 42 mgd City of Anacortes WTP
    - 120 mgd City of Everett WTP
    - 120 mgd Tolt WTP, Seattle Public Utilities
    - 150 mgd Green River Filtration Facility, Tacoma Water (largest media filter plant in the Northwest)
  - Oregon:
    - 61 mgd Duff WTP, Medford Water Commission
    - 80 mgd Hayden Bridge WTP, Eugene Water and Electric Board
    - 85 mgd Joint Water Commission WTP (largest operating media filter plant in Oregon)
    - 145 mgd Bull Run WTP, Portland Water Bureau (in design)
  - Other West Coast WTPs
    - 475 mgd Seymour Capilano Filter Plant, Vancouver, BC (largest Canadian media filter plant)
    - 140 mgd Harry Tracy WTP, San Francisco, CA
    - 750 mgd Joseph Jensen WTP, Los Angeles, CA
- **Membrane filtration:** Membrane filtration has been slow to implement in North America for large-scale WTPs due to higher capital and operating costs. The following are Northwest examples of membrane filtration WTPs:
  - Washington and Oregon:
    - 15 mgd Columbia River WTP, City of Kennewick, Washington (largest membrane plant in the Northwest)
    - 11.8 mgd Bridge Creek WTP, City of Bend, Oregon (largest membrane plant in Oregon)
  - Other West Coast WTPs
    - 42 mgd Water Treatment Centre, Kamloops, BC (largest membrane WTP in Canada)
    - 100 mgd Twin Oaks Valley WTP, San Diego, CA (largest drinking water membrane WTP in North America).

Since the 2001 feasibility study, all new and expanded WTPs in the Northwest larger than 30 mgd have been granular media filtration.

### 5.1.1 Granular Media Filtration

Granular media filtration involves the filtration of source water through one or more layers of granular media. Particulate matter in the applied water is retained on and around the media. Two common types of granular media filters are used for surface water treatment: rapid granular media filters and biologically active filters (BAFs). Rapid granular media uses a combination of anthracite, silica sand, and garnet sand to physically remove particulates. The Anacortes and Everett WTPs in Washington are rapid granular media filters, as are the Joint Water Commission and Hayden Bridge WTPs in Oregon.

BAFs provide additional removal of organics, resulting in better DBP control and a more biologically stable filter filtrate relative to granular media filters. BAF design is very similar to rapid media filters but typically has larger media and/or deeper beds to promote biofilm growth. In addition, these type of filters typically replaces anthracite and silica sand media with granular activated carbon (GAC). GAC is most amenable to biological growth because the porous particle surface is more capable of supporting higher biological concentrations than hard, angular anthracite. The filters are often preceded by ozonation to convert undesirable organic molecules present in raw water into smaller organic molecules that are readily consumed by microbiological activity growing in the filter. The benefits of BAF relative to rapid media filters are as follows:

- Production of a more biologically stable water that reduces distribution system regrowth.
- Higher removal of organic precursors to DBP formation.
- Greater reduction in the filtered water chlorine demand, thereby improving chlorine residual stability and reducing DBP formation.
- Greater removal of color compounds.
- Removal of taste-and-odor compounds.

While not designed as such, the Tolt WTP and the Green River Filtration Facility operate as BAFs.

### 5.1.2 Membrane Filtration

Membrane filtration is based on physical separation as presented in Figure 2. The membrane filtration types typically used for filtration of surface water are low-pressure microfiltration (MF) and ultrafiltration (UF). The MF/UF membrane filtration systems installed for surface water treatment are characterized as follows:

- Most proprietary MF/UF systems use hollow-fiber membrane filaments.
- Most hollow-fiber membranes are typically made polymers. Polymeric membranes have high chemical resistance and tolerance to feed turbidity. Recently, ceramic membranes have been introduced that are even more resistant to chemicals and turbidity.
- Polymeric membrane life expectancy is typically 7 to 10 years. Ceramic membranes last multiple decades.
- Short-duration air-scour and flushing processes are conducted periodically to remove the accumulated particles from the membrane surface.
- Chemical cleaning processes are conducted periodically to remove the foulants from the membranes.

The principal advantages of membrane filtration over granular media filtration is their more compact footprint, lower capital cost, and the ability to readily smaller particles than granular media filtration, such as viruses and microplastics. The smaller particles includes many organics that slip past granular media filtration to exert chlorine demands and potential bacterial regrowth within the distribution system.

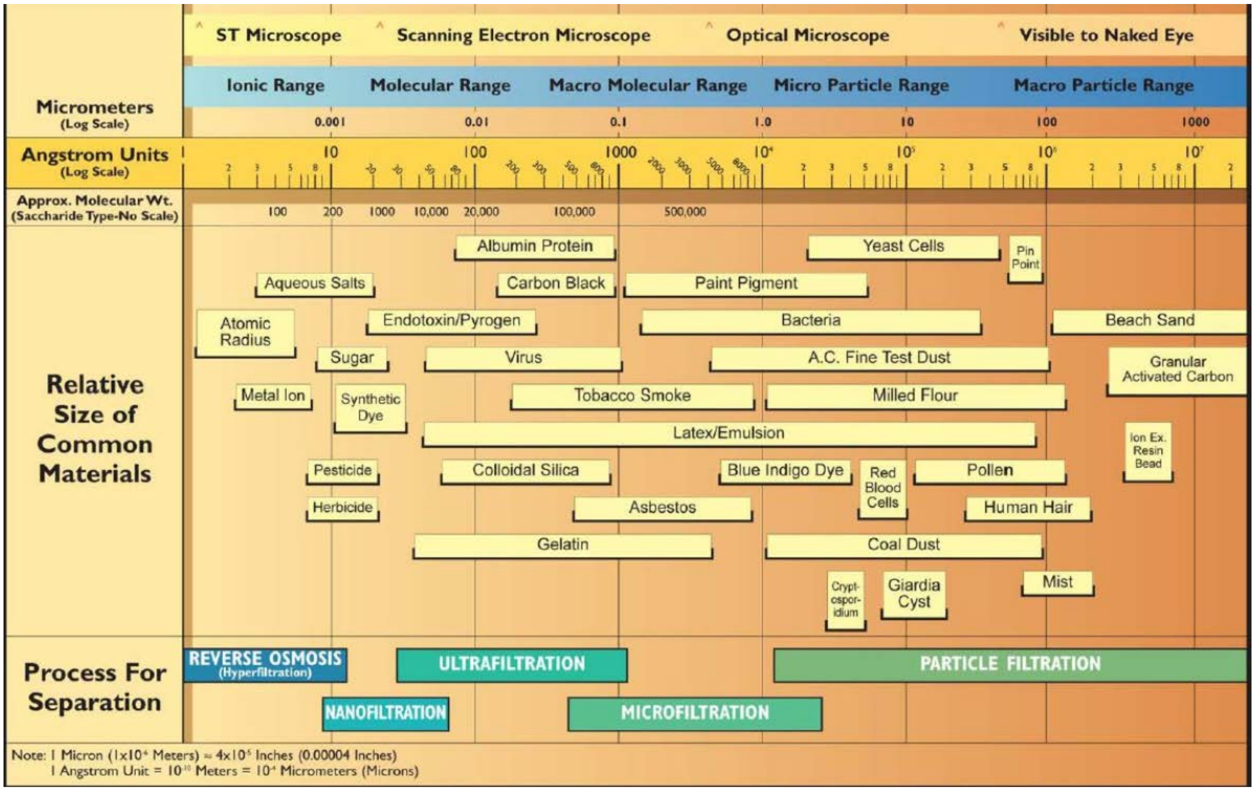


**Figure 2. Filtration spectrum**

Source: Osmonics 2020.

The following are major disadvantages to using a membrane filtration system for the Lake Tapps WTP compared to granular media filtration:

- Higher O&M and lifecycle costs.
- Membranes experience various types of fouling that require regular acid and biocide chemical cleanings, cleanings that are not required for granular media filtration.
- Specialized vendor training is needed for operators to ensure that membranes are operated within their limits and avoid voiding stringent membrane warranty conditions. Granular media filtration does not have such warranties.
- Greater difficulties in treating waters with algae present.
- Can be readily destroyed with exposure to hydrocarbons (grease, oils, diesel, gasoline, kerosene/jet fuel). Granular media filtration is incapable of removing these contaminants but will not be destroyed upon exposure, whereas BAF can actually remove a small fraction of these contaminants.

### 5.1.3 Filtration Recommendation

Both granular media filtration and membrane filtration are capable of treating water from Lake Tapps to . However, granular media filtration, and specifically BAF, is the recommended filtration process for the Lake Tapps WTP based upon the following differential water quality benefits:

- **More biologically stable water:** BAF is likely to provide a reduction of total organic carbon (TOC) of about 60 to 80 percent, which is higher than having rapid granular media filtration and equal to membrane filtration. This provides a more stable distribution system water.
- **Ease in achieving DBPs target goal:** BAF, and membranes, more readily reduces DBP formation to the treated water goals of less than 10 micrograms per liter (µg/L) than rapid granular media filtration.
- **Greater volatile and synthetic organic compounds reduction:** The recent Lake Tapps Reservoir water sample results do not show volatile organic compounds (VOCs) or synthetic organic compounds (SOCs) exceeding the treated water goals. BAF is more effective for removing VOCs and SOCs if these compounds loading increases in the lake or if future regulatory requirements are lowered for these types of compounds than the other two filtration processes.
- **Greater herbicides and pesticides removal:** Herbicides and pesticides are either VOCs or SOCs. The Lake Tapps Reservoir water sample results does not have these types of compounds exceeding the treated water goals. Similar to VOC and SOC removal, BAF is more effective at removing herbicides and pesticies if these compounds loading increases in the Lake or if future regulatory requirements are lowered for these types of compounds. .
- **Resistance to potential algal blooms:** BAF, and rapid granular media filtration, has a greater ability to successfully treating water with algal blooms compared to membrane filtration.
- **Ability to survive and treat exposure to hydrocarbons:** BAF can remove a small fraction of hydrocarbons upon exposure whereas rapid granular media filtration has no removal and membranes can suffer extensive damage and may actually be destroyed upon exposure.

## 5.2 Pretreatment

The intent of pretreatment is to enable removal of particulate and dissolved contaminants in the raw water prior to the filtration process.

### 5.2.1 Removal of Particulate Matter and Other Contaminants

Water samples from Lake Tapps Reservoir show a median water turbidity of 6.9 NTU and 1.3 NTU at the tailrace and outlet, respectively, which indicates that the reservoir provides some level of pretreatment in that it effectively serves as a large sedimentation basin. Much of the particulate matter present in water from the White River and any other point or nonpoint sources that enter the reservoir that have sufficient density can physically settle within the reservoir and will be removed prior to entering the WTP. A high fraction of sand and grit can be expected to be removed by this process. However, silt and clay particles and free-floating algae that have lower relative densities will not be as effectively removed by physical settling; these particles can be expected to remain suspended in the raw water and will need to be removed at the WTP.

The pretreatment phase of the proposed treatment train will include screening and chemical addition followed by rapid mixing, flocculation, and dissolved air flotation (DAF). The pretreatment components and their purposes are summarized below:

- Bar screens and mechanical traveling-band screens to remove debris such as sticks, leaves, trash, and other particles that may interfere with subsequent treatment steps.
- A coagulant chemical such as aluminum chlorohydrate (ACH) and polyaluminium chloride (PACl) is introduced in the raw water in a rapid-mix step, followed by flocculation to promote aggregation of the suspended particulates. This flocculation process will create larger and denser particles that are easily removed by downstream solids separation processes (DAF and BAF).
- A coagulant chemical to reduce NOM prior to the DAF and disinfection process. NOM is a precursor of DBPs. Once attached to particles, these dissolved species can be removed from the water in the DAF step.
- DAF to reduce the levels of suspended particulates.
- DAF is also effective for hydrocarbon (oil and grease) removal. Nonpoint sources of hydrocarbon contamination to Lake Tapps Reservoir include stormwater runoff and recreational boating. The treated water goal set for oil and grease is zero.
- Cyanotoxins reduction through DAF. As reported on the Washington State Toxic Algae website (King County 2019), cyanotoxins have been detected in Lake Tapps Reservoir with anatoxin-a concentrations of 0.55 µg/L (detected on October 15, 2019) and 0.015 µg/L (detected on November 6, 2019), and microcystin concentration of 0.15 µg/L (detected on October 15, 2019). DAF is effective for removal of intracellular cyanotoxins because many of the toxin-forming cyanobacteria are buoyant.
- Taste and odor reduction through DAF. Experience indicates that seasonal taste and odor compounds associated with algal blooms may occur in the reservoir. These taste and odor compounds are not readily removed using a coagulant chemical. Algal blooms occur when there are increased nutrient loads that can be contributed from wastewater discharge, agriculture runoff, and stormwater; warmer water temperatures; and sunlight (ultraviolet [UV] light). The DAF process has proved to be a highly effective technology for removing algae in raw water.

Therefore, it is recommended that a flocculation and DAF process train is best suited to treat raw water from Lake Tapps Reservoir, under both current and possible future water quality conditions. The closest existing WTP with an analogous treatment configuration is the 24 mgd Whatcom Falls WTP owned by the City of Bellingham, which treats a water supply very similar to Lake Tapps. Lake Whatcom is a relatively shallow man-made lake created by a diversion from another glacier-fed river (the Nooksack River) that often experiences elevated levels of algae and its associated issues.

### 5.2.2 Additional Benefits of Ozone in Pretreatment

Ozone is typically dosed ahead of the BAF process for the following additional benefits:

- Reduction of organic and inorganic matter. Lake Tapps Reservoir median dissolved organic carbon (DOC) is 1.9 mg/L, which creates taste and odor water issues, supports bacterial regrowth in the distribution, and acts as a precursor to DBPs. Ozone oxidizes DOC to produce organic compounds that are more readily removed by the downstream BAF system.
- Pesticides and herbicide reduction. Ozone is effective in the oxidative destruction of several pesticides and herbicides.
- It destroys several algal toxins.
- It reduces downstream chlorine consumption.
- Ozone is a best available technology for taste-and-odor control.

- Ozone provides additional pathogen disinfection.

The abovementioned reasons is why the Tolt WTP, Green River Filtration Facility use ozone along with Seattle's unfiltered Cedar WTP in Washington.

## 5.3 Post-Filtration

This section presents the recommended post-filtration treatment processes to meet the treated water quality goals.

### 5.3.1 Disinfection

Disinfection of the treated water is required after filtration to provide a secondary pathogen control barrier and distribution system protection. The disinfection processes and their applicability for the Lake Tapps WTP are described below:

- **Free chlorine:** Can be used as an oxidant in a pretreatment train, but is most commonly used as a disinfectant following the primary treatment processes. It provides a chlorine residual to control biological re-growth and associated problems in distribution systems. However, chlorine is not effective against *Cryptosporidium* protozoa and forms DPBs in the presence of organic matter.
- **Chlorine dioxide:** A very strong, unstable oxidant that is sometimes used for the destruction of organic compounds that contribute to tastes and odors in treated water. Chlorine dioxide must be formed on site by combining free chlorine with sodium chlorite, and thus requires more chemical storage and feed equipment to operate and maintain. Fewer than five Group A systems in Washington use chlorine dioxide, the largest being at the Judy Reservoir WTP owned by the Skagit Public Utility District. In addition, chlorite monitoring of the treated water is required per WAC 246-290-300.
- **Chloramines:** Chloramines are formed by reacting free chlorine with ammonia. Therefore, an ammonia feed system must be provided in addition to the free chlorine system. Chloramines are chemically weaker biocides than free chlorine and therefore must be held at higher residual concentrations than free chlorine to provide an equivalent level of secondary disinfection, but do provide a very stable disinfectant residual. Chloramines are not commonly used in systems that have cooler treated water temperatures and thus have limited use in Washington State.
- **Ozone:** Ozone is a very strong oxidant and is highly reactive; therefore, it must be generated on site. It has long been used in drinking water treatment for NOM oxidation, destruction of some algal toxins, and destruction of taste and odor–causing compounds; breaks down organic color-causing molecules; and reduces the use of downstream chlorine disinfectant. A secondary disinfectant such as free chlorine must be added to maintain necessary protection in the distribution system. In addition, ozone treatment requires monitoring of bromate per WAC 246-290-300.
- **UV light:** It is effective against bacteria, *Giardia lamblia,* and *Cryptosporidium.* A secondary disinfectant such as free chlorine must be added to maintain necessary protection in the distribution system.

Considering the above points, it is recommended that ozone be used for pre-filtration oxidation and free chlorine to provide a secondary disinfectant residual.

Per the EPA guidance manual for *Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Sources (*EPA 1990) for pathogen removal and contact time (CT):

- **Viruses log inactivation:** At a temperature of 7.8 degrees Celsius (°C), 5.2 milligrams-minute per liter (mg-min/L) free chlorine CT is required to achieve the 3-log virus inactivation. Therefore, with conventional filtration providing 2-log removal, the total removal is 5-log and it meets the treated water goal.
- ***Giardia lamblia* log inactivation:** At a temperature of 7.8°C, 0.82 mg-min/L ozone CT is required to achieve the 1.5-log *Giardia* inactivation. Therefore, with conventional filtration providing 2.5-log removal, the total removal is 4-log and it meets the treated water goal.

To achieve the total removal rate for *Cryptosporidium* to the treated water goal of 3-log, UV is typically applied post-filtration. The required UV dose is 2.5 millijoules per square centimeter ($mJ/cm^2$) to achieve an additional 1-log inactivation over the 2-log inactivation provided by pretreatment and filtration, per EPA 2006. This UV dose will also provide an additional 1-log inactivation for *Giardia*.

The proposed treatment combination of sedimentation, chemical coagulation, DAF, ozone, BAF, and chlorination is well suited to achieve the treated water goals for:

- DBPs of less than 10 µg/L
- Total coliform of zero colony-forming units per liter (CFU/L)
- 3-log removal/inactivation of *Cryptosporidium*, 4-log removal/inactivation of *Giardia lamblia*, and 5-log inactivation of viruses

### 5.3.1 Corrosion Control/Blending

As described in the Task 100 TM (HDR 2020), treated water from Lake Tapps Reservoir will be blended with other water supplies from SPU and TW and therefore will need to meet the below treated water quality conditions:

- pH of 8.2
- Calcium of 7.8 to14.0 as calcium carbonate ($CaCO_3$)
- Hardness of 14 to 25 as $CaCO_3$
- Alkalinity of 20 to 25 mg/L as $CaCO_3$

The pH ranges from 7.4 to 7.6 (median of 7.5), and the total alkalinity from 20.0 to 20.7 (median of 20.5) mg/L as $CaCO_3$ in Lake Tapps. Therefore, it is recommended that sodium hydroxide (caustic soda) be applied at a dose of approximately 0.5 mg/L (median) to raise the pH and total alkalinity to the treated water goals set point.

The concentrations of calcium and hardness in Lake Tapps raw water are at the treated water goals and will not need any adjustment.

### 5.3.2 Fluoridation

The three most commonly used fluoride compounds in water treatment are sodium fluoride, sodium silicofluoride, and fluosilicic acid. Fluosilicic acid will be used as it is currently being used by TW, SPU, and Everett City Utilities. The treated water fluoride concentration of 0.7 mg/L is required to blend with SPU and TW water supplies.

## 5.4 Proposed Treatment Process

Based on the treatment process selection analyses described in previous sections, the proposed treatment process for the Lake Tapps WTP is illustrated in Figure 3. Table 1 summarizes the WTP design criteria identified for this high-level study and compares it with the WTP description from the 2001 feasibility study.

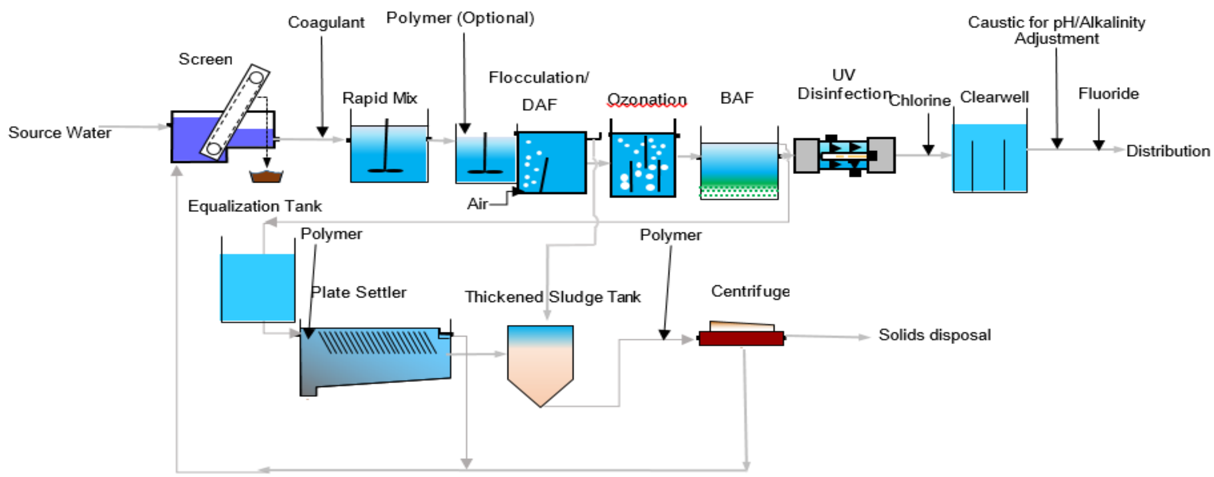


**Figure 3. WTP process schematic**

**Table 1. WTP Design Criteria**

| Description | Treatment Criteria in 2001 Feasibility Study | Treatment Criteria for this study |
|---|---|---|
| Screening | Not described | 0.25-inch bar screen and 0.08-inch traveling-band screen opening size. |
| Coagulant dosing | 5 mg/L average and up to 25 mg/L using aluminum chlorohydrate | No change |
| Flash mixer detention time | Not described | 15 seconds |
| Flocculation detention time | 20 minutes | 10 to 20 minutes |
| Sedimentation/ clarification | None | Dissolved air flotation |
| Other pretreatment | Seasonal powdered activated carbon for taste-and-odor control | 2 mg/L ozone for BAF, additional disinfection, taste-and-odor control, algal toxin destruction, and VOC/SOC destruction. |

| Description | Treatment Criteria in 2001 Feasibility Study | Treatment Criteria for this study |
|---|---|---|
| Filter aid polymer dosing | Could not be used | Up to 1.5 mg/L |
| Filtration | Submerged membranes with flux of 30 gallons per day per square foot during summer and 23 gfd during winter. | Biologically active filtration with GAC over silica sand media. Filter loading rate of 5.5 gpm/ft$^2$ and 20 minute empty bed contact time. |
| Chlorine residual | 1.0-1.5 mg/L as free chlorine | 1.5 mg/L as free chlorine and up to 3 mg/L |
| Fluoride dosage | 1 mg/L (optional) | 0.7 mg/L |
| Corrosion control | 2 mg/L carbon dioxide (average) and up to 10 mg/L | 0.5 mg/L caustic soda (average) and up to 1 mg/L |
| Other post-treatment | Potential granular activated carbon for additional taste-and-odor control and algal toxin removal | UV treatment sufficient to achieve 1-log *Cryptosporidium* inactivation |

# 6. Residuals Management

The objective of residuals management is to increase the overall WTP production efficiency.

The WTP efficiency is determined by comparing the water produced (i.e., sent to the distribution system) to the volume of raw water entering the WTP. The main residual waste streams from the WTP will be from the BAF filters and DAF system. The three disposal methods for these side streams are as follows:

- Direct discharge to sewer or surface water
- Treatment and discharge to sewer or surface water
- Treatment and recycle to head of the WTP

As per WAC 246-290-660 for filtration, if the purveyor chooses to recycle then the recycle streams will need to return to the head of the WTP, prior to the coagulant dosing. The side streams will contain solids that need to be removed before recycling. The water recycle increases the WTP's overall water production efficiency. For the WTP, the following are the two options to reduce waste streams:

1. **Flow equalization tanks, membrane filtration, gravity thickeners, and centrifuge/belt press:**
   The membrane plant would have an assumed firm capacity of 3.5 mgd to treat the residual waste streams and would also operate at a 90 percent recovery rate. The membrane flux would vary between 20 and 30 gallons per square foot per day (gfd) depending on the water temperature and turbidity. The recovered water would be sent back to the head of the WTP.

Concentrating the solids with membranes would reduce the flow rate to the solids thickening and dewatering facilities from 3.5 mgd to 0.35 mgd.

2. **Flow equalization tanks, plate settlers, gravity thickeners, and centrifuge:**
   In contrast to option 1, the plate settlers would have an average recovery of 80 percent and increase the flow downstream to 0.7 mgd.

Option 2 is the preferred option considering the high O&M cost that will be required to maintain the membrane filters. The 0.7 mgd waste stream from the plate settlers would be thickened with gravity thickeners. The gravity thickener underflow would be dewatered using centrifuges with output solids concentration minimum of 20 percent by weight. The dewatered solids from the centrifuge are then sent to temporary dumpsters. It is assumed that residual solids from the treatment process are disposed of off site.

# 7. Potential Measures to Implement Now to Avoid or Minimize Future Treatment Processes

Lake Tapps Reservoir water quality may deteriorate over time from stormwater runoff to the lake, and as the local population grows,  man-made waste from construction, littering and others are disposed to the lake. This section identifies pollution control measures for Lake Tapps Reservoir that can be implemented in the near term by Cascade to avoid or minimize the need in the future to install further treatment processes.

Currently Lake Tapps Reservoir is not being used as a source of potable water. Therefore, source protection and control measures, per DOH requirements, have not been previously established for this reservoir.

Cascade will need to work with local agencies to prevent further pollution of Lake Tapps Reservoir and implement the following suggestions to minimize future further treatment processes:

- On agricultural lands operation surrounding Lake Tapps Reservoir (agricultural operation is currently shown to be in east of Lake Tapps Reservoir):
    - Promote agricultural practices that keep soil, manure, fertilizers, pesticides, and other agricultural contaminants out of the reservoir
    - Install fencing that prohibits livestock access to the lake where applicable
    - Start acquiring development rights that limit agriculture-to-urban conversions or begin agriculture-to-forestry conversion
- On suburban and rural lands surrounding Lake Tapps Reservoir:
    - Incorporate stormwater wetlands and bioretention basins to provide treatment
    - Reduce the amount of impervious surface
    - Reduce water runoff from high-pollution areas such as parking lots
    - Control erosion, runoff, and sedimentation, especially during construction
    - Develop criteria for siting and maintaining septic systems
    - Limit use of lawn fertilizers and pesticides
    - Properly dispose of household chemicals
- Others:

- o Flush more water within the parameters of water rights through the lake to reduce stagnation zones and to help purge algae out of the water column
- o Dredge the lake to make the lake deeper—greater sedimentation and less macrophyte growth that can release TOC/NOM
- o Work with the Crystal Mountain wastewater treatment plant and other wastewater treatment plants that discharge to White River upstream of Lake Tapps to land-apply treated effluent or implement reuse to minimize secondary effluent discharge to the river; alternatively, work with it to implement enhanced nutrient removal, especially phosphorus
- o Consider stocking the lake with native fish that eat algae
- o Start acquiring lakefront properties
- o Set development setbacks to provide a natural buffer from direct sources of contamination
- o Preserve and protect trees and vegetated buffers along the shoreline
- o Ensure that septic tanks are inspected at least every 3 years by a septic service professional
- o Connect homes' sewer to a main sewer line/community wastewater treatment plant
- o Post local safety signs to remind people about pollution prevention
- o Develop education and outreach programs that support voluntary Lake Tapps Reservoir protection activities

# 8. Potential New and Emergent Water Quality Issues and Qualitative Treatment Impacts

The following new and emergent water quality issues based on recent pending drinking regulations have been presented in the Task 100 TM (HDR 2020):

- Lead and Copper Rule
- Per- and polyfluoroalkyl substances (PFAS)
- Algae and algal toxins

Based on these water quality issues, their treatment impacts to the proposed treatment process (Section 5.4) will be qualitatively analyzed.

## 8.1 Lead and Copper Rule

There will be no lead and copper issue in the distribution as corrosion control will be practiced in the proposed WTP. Therefore, qualitative treatment impact is not foreseen.

## 8.2 PFAS

No PFAS impacts to the treated water quality are foreseen as the raw water does not have any PFAS issue. The best solution to reduce the treatment impact of PFAS concentrations if they occur would be to feed powder-activated carbon (PAC) for adsorption upstream of the DAF process or add GAC filters downstream of the BAF process.

## 8.3 Algae and Algal Toxins

Algae and algal toxins in raw water and their treatment are discussed above in Section 5. The combination of DAF to remove intact algae cells, combined with ozone and free chlorine to destroy any released toxins, is a very effective combination in the proposed WTP treatment process. Therefore, additional qualitative treatment impact is not foreseen.

# 9. References

EES (Economic and Engineering Services) and HDR (HDR Engineering, Inc). 2001. *Lake Tapps Reservoir Water Right Technical Memorandum No. 5: Public Water Quality Analysis Water Treatment Plant Feasibility Study*, Bellevue, Washington.

EPA (U.S. Environmental Protection Agency). 1990. *Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources*. EPA Contract 68-01-6989. Washington, D.C.

EPA. 2006. *Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Tule*. EPA 815-R-06-007. Washington, D.C.

HDR. 2005. *Lake Tapps Water Treatment Plant: Review of Plant Physical Size and Location Requirements.* Bellevue, Washington.

HDR. 2020. *Lake Tapps Reservoir Water Treatment Feasibility Update: Establishment of Treatment Goals Update*. Bellevue, Washington.

King County. 2019. Washington State Toxic Algae. Fresh Water Algae Bloom Monitoring Program. Viewed March 6, 2020, https://www.nwtoxicalgae.org/Default.aspx

Osmonics. 2020. *The Filtration Spectrum*. Viewed February 27, 2020,

https://osmonicsrosystem.com/?gclid=EAIaIQobChMIi9-d1vvy5wIVT9bACh264QhHEAAYASAAEgIVXPD_BwE

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